

ADVANTEST®

K0312

TR41301

External Keyboard

Operator's Guide

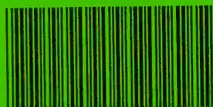
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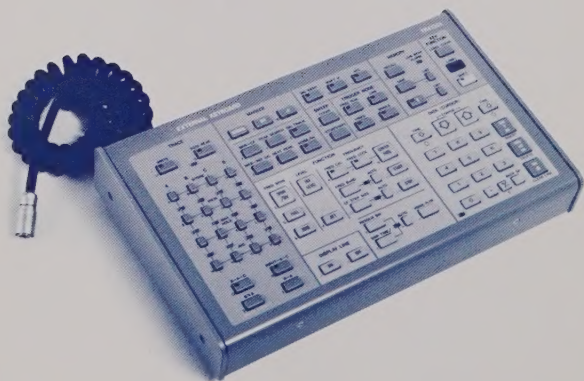
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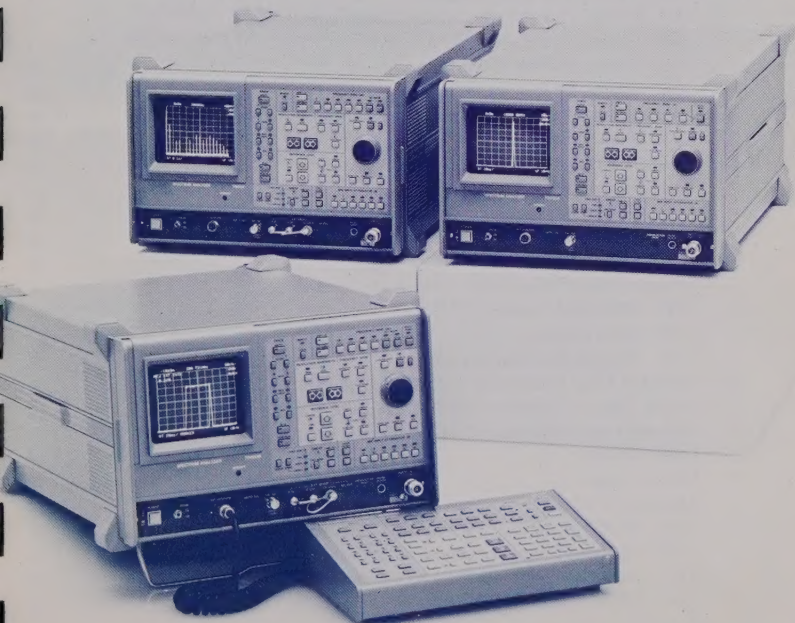
This Operator's Guide describes the basic operating procedures for the **TR4133** series of spectrum analyzers operated by the **TR41301** External Keyboard. For detailed description of the equipment, refer to the **TR41301** and **TR4133** series instruction manuals. Note that in response to user demand, further improvements in ADVANTEST's quality control system may result in certain parts of this manual being modified without prior notification.



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TR41301

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1. Preface

The **TR41301** external keyboard has been specifically designed for use with the high-grade **TR4133** series of portable spectrum analyzers. In addition to expanding the **TR4133** series memory and marker functions, and saving/recalling a maximum of 12 panel setting combinations, the **TR41301** also enables direct output of screen displays to a plotter device and measurement of occupied bandwidth and adjacent channel leakage power.

Always check the following points before using the **TR41301**

- Whenever the **TR41301** is connected to a **TR4133** series spectrum analyzer, make sure the analyzer unit power has been switched off.
- The **TR41301** is equipped with a lithium battery for memory back-up purposes. This battery can maintain the memory for at least three years. The battery must be replaced once the LOW BATTERY ALARM in the top right hand corner of the keyboard comes on (see Figure 1-1). Please contact your nearest ADVANTEST's representative for battery replacement details.
- Also check other precautions described in the **TR4133** series instruction manual before switching the power on and connecting calibration and other input signals.

WARNING

The maximum input levels which can be applied to the INPUT connector of **TR4133** series analyzers with an input attenuator of at least 20 dB are +20 dBm, +127 dBm μ , +110 dBp, and 0 Vdc. Input of voltages in excess of these levels will result in damage to the input mixer stage which is very expensive to repair. Where there is risk of the input signal level exceeding this maximum level, use an external attenuator or similar means to ensure that the level is adequately reduced.

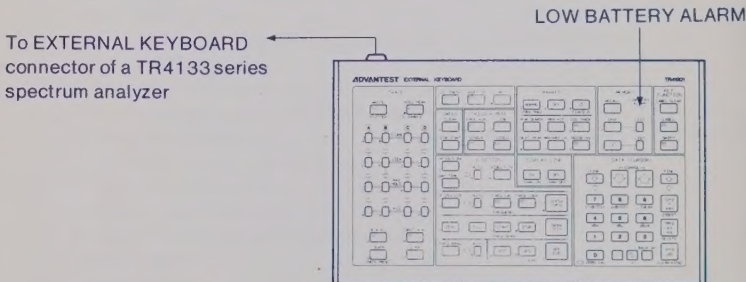


Fig. 1-1 LOW BATTERY ALARM

1.1 Screen Display

The screen displays measured data and the various measuring condition settings. (See Figure 1-2)

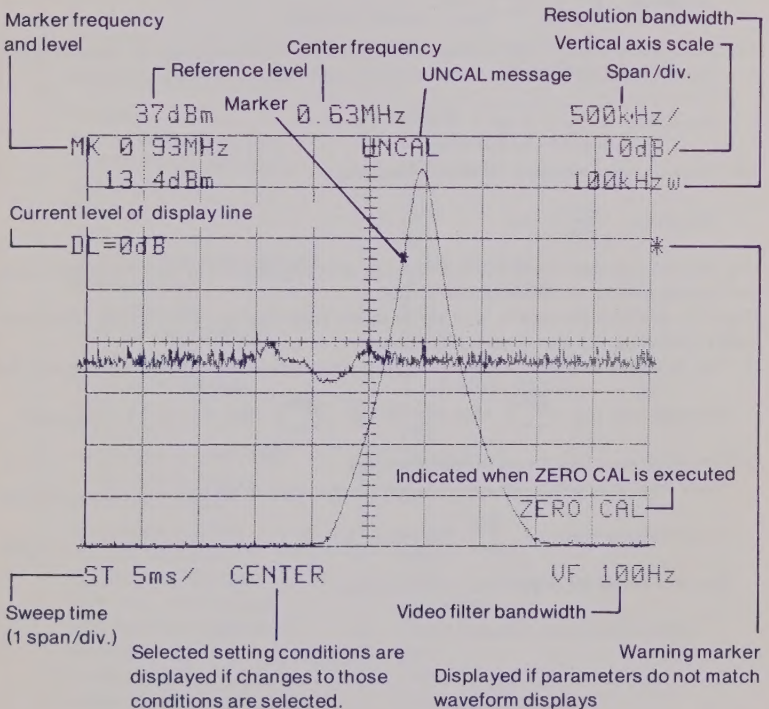


Fig. 1-2 TR4133 series spectrum analyzer screen readout

2. Basic Operations and Key Functions

The **TR41301** keyboard key functions are basically the same as the **TR4133** series spectrum analyzer panel key functions. There are three main types of keys.

- (1) Keys where the corresponding function is executed when that key is pressed.

Examples:   etc.

- (2) Keys which result in the setting mode of specific functions being set when pressed, thereby enabling the desired conditions to be set by ten key or step key operation.

Examples:    etc.

- (3) Keys equipped with both (1) and (2) functions.

Examples:  etc.

The selected operating mode of all functions can be readily checked by the built-in key LEDs, and messages on the bottom line of the screen.

The KEY numbers allocated to each key as shown inside the back cover of this manual are used in describing key operations in the main text.

- The functions indicated in yellow or green characters below certain keys can only be activated when the  (Key No. ③⑦) or  (Key No. ③⑥) key is pressed.

- One of the most useful keys to remember first:
Many measuring conditions are set by ten key operation. If the incorrect value is exceeded by mistake, press the  key (Key No. ⑦①) to clear input characters one at a time and enable the correct input to be keyed in.

2.1 Initialization

The default values set automatically when the power is switched on are listed in Table 2-1. The analyzer unit can be reset to the initialized state during any operation by pressing

the  (Key No. ③⑦) and  (Key No. ⑨) keys.

Table 2-1 Default values

Function	Default value
TRACE	WRITE
A/D SAMPLING MODE	POSI NEGA (+, -) PEAK
SWEEP TRIGGER MODE	FREE RUN
SIGNAL IDENT	OFF
SHIFT IF	OFF
AFC	OFF
RESOLUTION BANDWIDTH	1 MHz (AUTO)
SWEEP TIME	10 msec/(AUTO)
VIDEO FILTER	OFF
CENTER FREQUENCY	0 MHz
CF STEP SIZE	AUTO (400 MHz)
FREQUENCY BAND	0 - 3.6 GHz (AUTO)
FREQ CAL	OFF
FREQ LOCK	OFF
FREQUENCY SPAN/DIV	400 MHz
START FREQUENCY, STOP FREQUENCY	OFF
REFERENCE LEVEL	0 dBm
REFERENCE UNIT	dBm
REFERENCE OFFSET	0 dB
VERTICAL AXIS SCALE	10 dB/DIV
MIN. INPUT ATTENUATOR	10 dB (selected value also 10 dB)
MARKER	OFF
DISPLAY LINE	OFF
LABEL	OFF
SHIFT	OFF

2.2 Setting of Basic Measuring Functions (FUNCTION Section)

2.2.1 Frequency Band Selection

Step	Key No.	Key pressed	Screen display and results
1	(46)		Analyzer set to "FRQBND" frequency band setting mode.
2	(61) ~ (68)	 	The frequency bands in the following table can be selected.

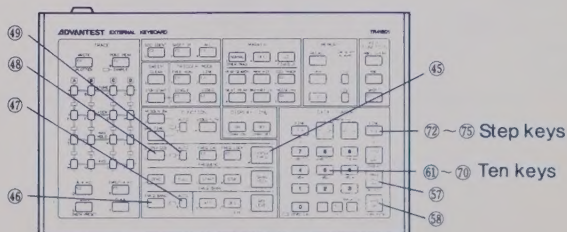
Table 2-2 Ten keys and corresponding frequency bands

Model	Setting (Ten key)							Unit: GHz
								
TR4133	0-0.36	0.01-4	4-12	8-12	12-20	12.4-28	28-60	
TR4133A/B	0-0.35	3.5-7.5	7.2-15.2	10.9-20	12.4-28	28-60	3.5-20	

2'	(74) (75)	 	Frequency bands can be changed one band at a time by using the step keys instead of ten keys.
3	(58)		Operation is commenced in the selected frequency band.

And if the AUTO function is used,

(47)		The optimum frequency band is selected automatically when in center frequency setting mode or FREQUENCY LOCK mode.
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2.2.2 Center Frequency Setting

Step	Key No.	Key pressed	Screen display and results
1	(45)		Analyzer set to "CENTER" center frequency setting mode.
2	(74) (75)	 	The center frequency can be increased/decreased by 1 SPAN/DIVision. Likewise, 1/20 SPAN/DIV increments/decrements are possible. The amount of increments/decrements is set by the STEP SIZE setting described below.
	(72) (73)	 	

2' The desired center frequency can also be set numerically by ten key and unit key operation.

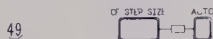


The center frequency is set to 123 MHz in this example.

(1) STEP SIZE setting

Step	Key No.	Key pressed	Screen display and results
1	48		Analyzer set to "CFSTEP" center frequency STEP SIZE setting mode.
2		  	"CF STEP SIZE 456" is displayed.
3	(57)		The step size of the STEP key is thus set to 456 MHz.

And if the AUTO function is used,

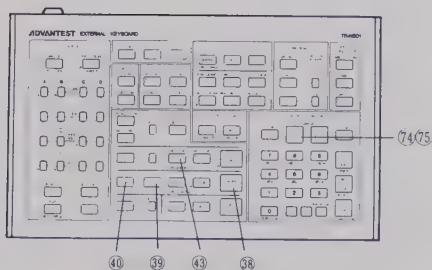


The CF STEP SIZE is always set automatically to match SPAN/DIV.

(2) FREQuency CALibration

When SPAN/DIV lies in the 50 kHz to 50 MHz range, any discrepancy between the center frequency and waveform displays must be corrected by using this procedure before frequencies are measured. Discrepancies arise from YTO synchronization hysteresis in the **TR4133** series 1st local oscillator. The correction is completed in a few seconds. This procedure is not required when SPAN/DIV is less than 20 kHz since the correction is performed automatically in that case.

Key No.	Key pressed	Screen display and results
43		The center frequency accuracy is set to $\pm(1 \text{ MHz} + 20\% \text{ of SPAN/DIV})$. On rare occasions, the TR41301 may fail to execute this calibration routine correctly. In this case, however, the "CNT ERROR" message appears and the buzzer is activated to inform the operator that the key is to be pressed a second time.



2.2.3 Frequency Span Setting

Select the required function from the frequency span alternatives — FULL SPAN (sweeping of the entire bandwidth), SPAN/DIV selection, and ZERO SPAN (time axis display) — displayed on the screen.

(1) FULL SPAN

Key No.	Key pressed	Screen display and results
③⑨		Analyzer set to FULL SPAN mode. The entire bandwidth of the set frequency band is swept and displayed.

(2) SPAN/DIV

Step	Key No.	Key pressed	Screen display and results
1	③⑧		Analyzer set to "SPAN/" SPAN/DIV setting mode.
2	⑦④ ⑦⑤		SPAN/DIV changed in 1-2-5 steps in 2 kHz — 400 MHz range. ● Setting by ten key operation also possible, but only in the above steps.

(3) ZERO SPAN

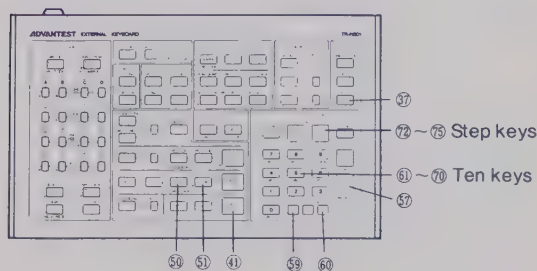
Key No.	Key pressed	Screen display and results
④①		Analyzer set to ZERO SPAN mode where it operates as a receiver tuned to the center frequency. This mode is used for measuring demodulation of modulated signals and monitoring of independent signals.

(4) Sweep START/STOP frequency setting

Step	Key No.	Key pressed	Screen display and results
1	(50) / (51)	 / 	Current sweep START/STOP frequencies are displayed as "START xx MHz" and "STOP xx MHz." A vertical cursor line appears on the sweep start/stop frequency axis, and the START/STOP frequency is indicated by display of the cursor frequency.
2	(74) (75)	 	The sweep start/stop frequency (cursor) is shifted 1 SPAN/DIV.
	(72) (73)	 	Cursor shift by one point to left or right. If the cursor is at the left or right hand side of the screen when either of these step keys is pressed, the frequency span is shifted by one division.

These frequencies can also be set by ten key operation.

2'      "START/STOP 1023 MHz" is set.



2.2.4 Setting of Vertical Axis Conditions

(1) Reference level setting

The reference level (the level of the top line of the screen grid) can be displayed as a logarithmic or linear value. The default value for the vertical axis scale is 10 dB/div. (logarithmic display).

Step	Key No.	Key pressed	Screen display and results
1	41		Analyzer set to "REF" reference level setting mode.
2	73 ~ 74	  	Level can be set in the step sizes and within the setting range given in Table 2-3.

Table 2-3 REF LEVEL step sizes

	Vertical axis scale		
	10dB/DIV	2dB/DIV	LINER
COARSE step sizes	10dB	2dB	1-2-5 steps
FINE step sizes	1dB	0.25dB	
Setting ranges	+40dBm ~ -69.75dBm		20V ~ 100μV

And by ten key operation,

     "REF LEVEL - 21.5 dB" is set.

(2) Vertical axis scale changes

Step	Key No.	Key pressed	Screen display and results
1	41		Analyzer set to "REF" reference level setting mode.
2	37		SHIFT mode is selected.
3	69	 10dB/DIV	Vertical axis scale set to 10 dB/DIV.
	69	 2dB/DIV	Vertical axis scale set to 2 dB/DIV.
	70	 LINEAR	Vertical axis scale set to LINEAR. The unit is Vrms, and the bottom line is set to 0 V.

(3) DISPLAY LINE (horizontal cursor line) setting

When setting the DISPLAY LINE, setting in normal mode can differ slightly from when setting in  and  modes.

(a) Normal mode

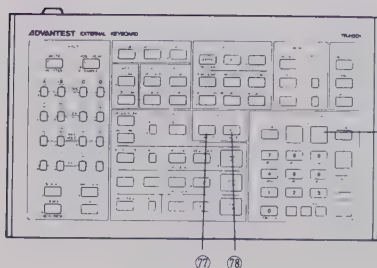
Step	Key No.	Key pressed	Screen display and results
1	77		"DISPLLN" DISPLAY LINE appears on the screen. The level is shown as "DL=xx", and the position can be set by step key and ten key operations. The step size is as shown in Table 2-4.

Table 2-4 DISPLAY LINE step sizes

2



Step key	When 10 dB/DIV.	When 2 dB/DIV.
COARSE	10dB	2.5dB
FINE	0.4dB	0.1dB



Any level can be set by ten key operation.







 "DL = -56.2 dB" is set.

3  

The DISPLAY LINE and corresponding data are cleared from the display.

(b)  and  modes.

When either of these keys is pressed, DISPLAY LINE is displayed as soon as that key is

pressed. If the  key is pressed, B = A is displayed for DL, and if the 

key is pressed, INPUT = A is displayed. Therefore, the DISPLAY LINE level display appears as "DL = 0 dB".

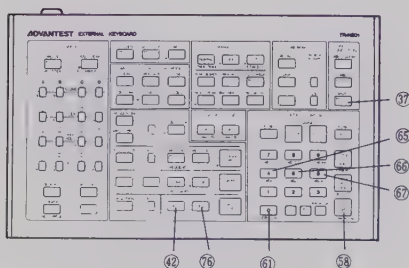
Step	Key No.	Key pressed	Screen display and results
1			Shift of the "DSPLLN" DISPLAY LINE is enabled. The DISPLAY LINE shift and B - A → C waveform data processing in this case takes about 1/4 sec., and during this interval, any new input data is disregarded. This point should not be forgotten when programming via GPIB.
2	  		Although the DISPLAY LINE can be shifted up and down, the display is always "DL = 0 dB", and up and down waveform movement follows the shift in this reference line. Setting by ten key operation is not possible.

- When another trace mode is used apart from  and  modes, the DISPLAY LINE functions as the normal level display.

(4) Changing the level display unit

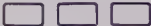
In logarithmic displays, the display units which can be selected for reference level, marker, and DISPLAY LINE are dBm, dB μ , and dBpW.

Step	Key No.	Key pressed	Screen display and results
1	(37)		Selection of SHIFT function
	(65)	 dBm	dBm selected as display unit
2	(66)	 dB μ	dB μ selected as display unit
	(67)	 dBpW	dBpW selected as display unit



(5) Setting reference level offset values

When the vertical axis scale is LOG, any desired offset value may be added to the reference level.

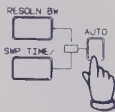
Step	Key No.	Key pressed	Screen display and results
1	(76)		"LVOFST" is displayed to indicate that the analyzer has been set to offset value setting mode.
2	Key in the offset value by ten key operation.		
			Operation is commenced. The level unit dBm, dBμ, or dBpW are effective. "OFST xx.xx dB" is displayed. The reference level, normal marker, and DISPLAY LINE levels are displayed with offset added to the actual values.
3	(76) (61) (58)	  	Offset released.

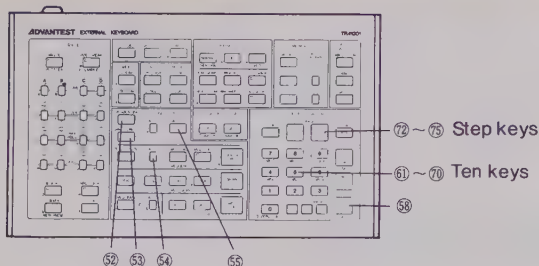
(6) Setting the minimum input attenuator value

Set the input attenuator to 50 dB if the level of the input signal is unknown, and then drop the level in 10 dB steps while watching the screen. The reference level is set once the input attenuator has been set. The input attenuator value is increased automatically if the reference level is raised, and decreased automatically if lowered (but not below the originally set value). And as a rule, the IF amplifier gain is controlled so that the reference level value remains unchanged if the minimum input attenuator value setting is changed.

Step	Key No.	Key pressed	Screen display and results
1	(42)		Analyzer set to "RFATT" MIN INPUT ATTENUATOR setting mode.
2	74 75	 	Setting is changed in 10 dB steps in the 10 dB to 50 dB range. 0 dB can only be set by ten key operation.
3	(61) (68)	 	Setting to value of 0 dB.

2.2.5 RESOLution BandWidth and SWEEP TIME/ Settings

Step	Key No.	Key pressed	Screen display and results
1	52		Automatic "RBW" resolution bandwidth and sweep time setting mode is cancelled, and manual setting mode is set.
2	(74) (75)		The resolution bandwidth is changed in 1-3 steps in the 100 Hz to 1 MHz range. Although ten key setting is possible, the setting can be made in 1 or 3 steps at a time.
3	(53)		Automatic resolution bandwidth and "SWP" sweep time setting mode is cancelled, and manual sweep time setting mode is set.
4	(74) (75)		Sweep time is changed in 1-2-5 steps in the 5 msec./div. to 10 sec./div. range. ● UNCAL message: Narrowing of the resolution bandwidth can result in an increased time constant and lowering of the level of the measured signal. In this case, the UNCAL message appears at the top of the screen to indicate that either the sweep time is to be increased, or SPAN/DIV is to be reduced.
In resolution bandwidth and sweep time AUTO mode,			
5	(54)		Optimum resolution bandwidth is set according to SPAN/DIV, and optimum sweep time is set according to the SPAN/DIV and VIDEO FILTER settings.

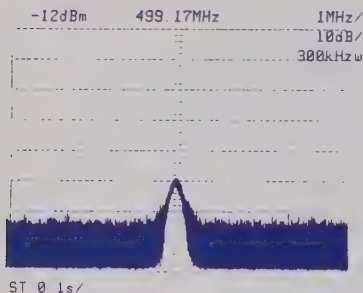


2.2.6 VIDEO FILTER Setting

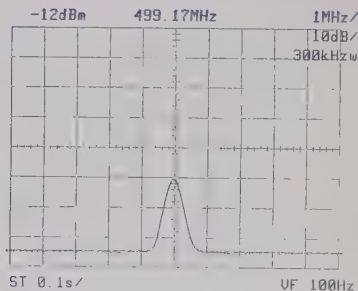
The VIDEO FILTER is used to improve the S/N ratio by averaging the noise (Figure 2-1)

Step	Key No.	Key pressed	Screen display and results
1	(55)		Analyzer set to "VF" VIDEO FILTER setting mode.
2	(72) ~ (75)	   	The filter's cut-off frequency can be set to the OFF, 10 kHz, 1 kHz, 100 Hz, or 10 Hz position.
	(62) (61) (58)	  	Although setting by ten key operation is also possible, only one of the five stages can be set.

- Although noise is averaged out more at lower filter cut-off frequencies, the signal waveform response deteriorates. Lowering the measuring level can result in display of the UNCAL message, indicating that the sweep time has to be increased.

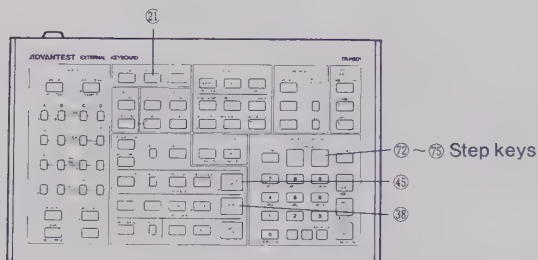


(a) VIDEO FILTER OFF



(b) VIDEO FILTER 100 Hz

Fig. 2-1 S/N ratio improvement achieved by VIDEO FILTER



2.2.7 Auxiliary Functions

(1) SIGNAL IDENTification

This function is used to identify measured signals, image signals, and multiple responses. Since the **TR4133A/B** analyzers are equipped with a pre-selector, image signals and multiple response appear very seldom. This function is most useful when the EXternal MIXER band is used in **TR4133/B** and when it is necessary to identify measured signals.

Step	Key No.	Key pressed	Screen display and results
1	(45)		Measured signal is set to center frequency.
2	38 74	 	SPAN/DIV is set to about 1 MHz/DIV.
3	(26)		A check signal appears at the side of the signal spectrum and at a level some 3 dB below the spectrum at each sweep. If the frequency difference between the signal spectrum and the check signal is less than 1 MHz, it signifies that the signal to be measured has been correctly obtained (see Figure 2-2).

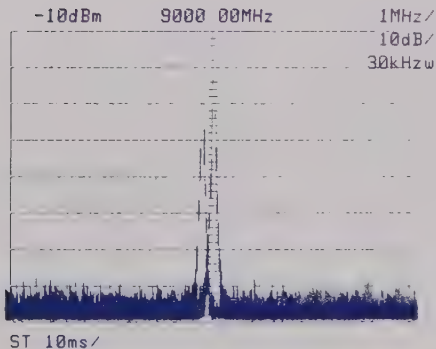
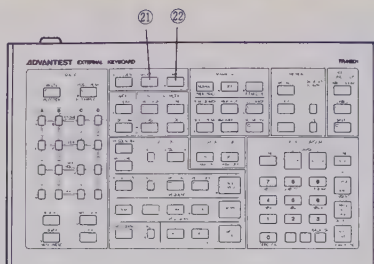
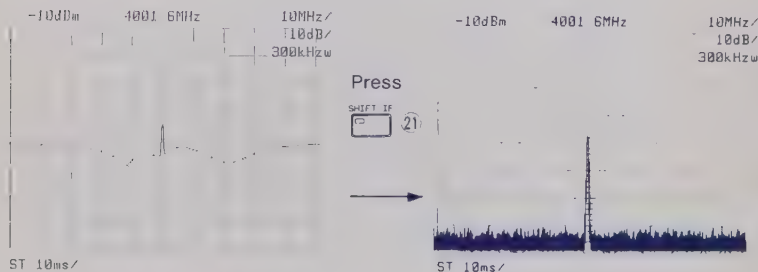


Fig. 2-2 SIG IDENT usage



(2) SHIFT IF

If a 4 GHz input signal is applied when the spectrum analyzer's IF frequency is 4 GHz, the base line is raised by IF feedthrough, and the measuring dynamic range is lowered. The base line shift can be prevented in this case by activating the SHIFT IF function to displace the IF frequency by about 5 MHz. This function is operative only when the frequency band is 0 ~ 3.6 GHz in **TR4133A** and when the frequency band is 0 ~ 3.6 GHz or when the EXTERNAL MIXER band is used in **TR4133/B**



Press key a second time to release SHIFT IF mode.

Fig. 2-3 SHIFT IF usage

(3) AFC (Automatic Frequency Control)

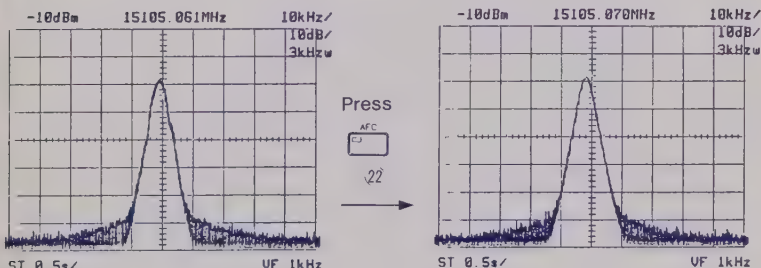
The AFC function is used to stabilize signals for measuring purposes when SPAN/DIV is less than 20 kHz.

Note that this function cannot be used for signals with levels below the minimum signal level in the following table, pulse modulated waves, and FM signals below 1 kHz.

Table 2-5 Minimum signal level at which AFC can be used

TR4133			TR4133A/B	
Frequency band		Input signal level	Frequency band	Input signal level
0-3.6GHz		-70dBm+ATT *	0-3.6GHz	-70dBm+ATT
0.01-4GHz		-60dBm+ATT	3.5-7.5GHz	-63dBm+ATT
4-12GHz	4-8GHz	-51dBm+ATT	7.2-15.2GHz	-57dBm+ATT
	4-12GHz	-48dBm+ATT	10.9-20GHz	-47dBm+ATT
8-12GHz		-55dBm+ATT		
12-20GHz		-47dBm+ATT		

* -70 dBm + input attenuator setting (ditto for all other levels)



Press key a second time to release AFC.

Fig. 2-4 AFC usage

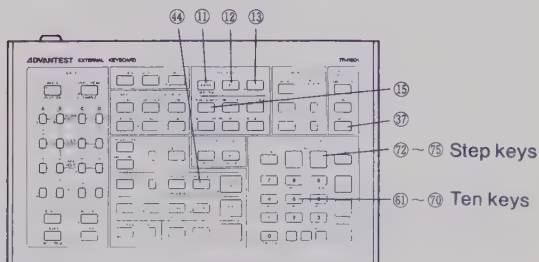
(4) FREQuency LOCK

Function used to fix the center frequency. This function can only be used if SPAN/DIV is less than 20 kHz, or if the analyzer is in ZERO SPAN mode.

Step	Key No.	Key pressed	Screen display and results
1	44		"FRLOCK" where the center frequency is adjusted for each sweep.
2	74 75	 	Fixed center frequency is increased/decreased by 1 DIV.

Setting is also possible by ten key operation.

2'	   	Center frequency set to 789 MHz.
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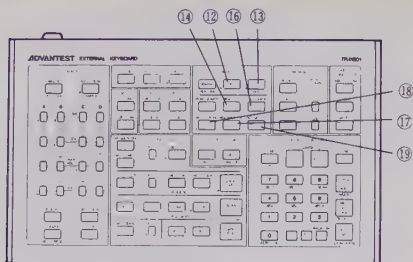


2.3 Setting of Marker Functions (MARKER Section)

Markers are used for direct reading of waveform data displayed on the screen.

(1) NORMAL marker

Step	Key No.	Key pressed	Screen display and results
1	(11)		"MARKER" appears on the center frequency axis, and marker frequency and level are shown as "MK xx Hz, xx dBm". The marker is shifted to the frequency axis by step key and ten key operations.
2	(74) (75)		Marker shifted by 1 div.
	(72) (73)		Marker shifted by one point (1/70 div.)
	1 2 3		Marker set to 123 MHz.
3	(15)		Marker shifted to the highest level frequency axis on the screen.
4	(37) 13	 	The marker position is fixed on the screen, and the frequency and level data is stored in memory. A second marker appears, and the frequency and level differences between the two markers are displayed. Note that this function differs slightly from the delta marker described below.
5	(37) 11	 	Marker shifted to the other trace if a dual-trace display is being used.
6	12		Markers and marker related data are cleared from screen.

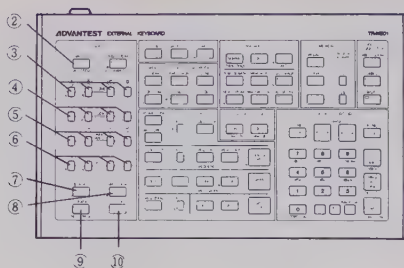


(2) Delta marker

Step	Key No.	Key pressed	Screen display and results
1	13		A second marker appears on the screen in addition to the NORMAL marker, and the marker data displayed ("MK Δxx Hz, xx dBm") is the differences in frequency and level. Only the second marker can be moved — the other marker being fixed as the reference marker. When is OFF, two markers appear on the center frequency axis, one marker being active. In addition to step and ten key operations, the active marker can also be moved by the and keys.
2	13		The reference marker is cleared, and the active marker becomes the new reference marker with one more marker appearing as the new active marker.
3	12		Markers and marker related data are cleared from screen.

(3) Other marker operation keys

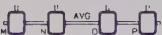
Key No.	Key pressed	Screen display and results
14	MKR → CF 	Marker frequency is set to center frequency. And in delta marker mode, the active marker is set in the same way.
16	SIG. TRACK 	The highest peak in each sweep is found, and the frequency of the peak is set as the center frequency. That is, the PEAK SEARCH and MKR → CF functions are executed for each sweep. This function is only valid when a marker is displayed. A buzzer is activated if this key is pressed with the marker OFF. And if trigger mode is switched to SINGLE, this function is suspended. This operation is not executed correctly if trace mode has not been set to WRITE.
18	NEXT PEAK 	The next highest peaks displayed on the screen are found. The waveform is usually held for this operation.
17	MKR → REF. LVL 	Marker level is set to reference level.
19	NOISE /Hz 	The noise level rms value normalized at 1 Hz noise power bandwidth can be measured by this function. The marker level is displayed as ".....dBm/Hz". This function can only be used when the vertical axis scale is 10 dB/div.



2.4 Setting of Trace Conditions (TRACE Section)

The **TR41301** enables to display the contents any two of the five memories (input waveform memory **WRITE**, and the computing memories **A**, **B**, **C**, and **D**) to be displayed simultaneously on the screen. The data corresponding to the last two **TRACE** keys to be pressed are displayed. For single screen displays, press the same key twice. Note that in computing display modes, two sets of data cannot be displayed simultaneously.

Key No.	Key pressed	Screen display and results
②		Display of input waveform memory WRITE contents. Memory contents are updated with each new sweep. WRITE mode is the default trace mode.
3		The final sweep of the input waveform data is stored in memory A (B , C , D). A still display of the contents appears on the screen (VIEW A (B , C , D) mode).

Key No.	Key pressed	Screen display and results
④		Press to call memory A (B, C, D) contents onto the screen.
⑤		The input waveform data is compared with memory A (B, C, D) data at each point on the horizontal axis. If the input data is higher at the point, the memory A (B, C, D) data is updated, and the trace of the peak data is displayed on the screen.
⑥		“AVG”. The memory A (B, C, D) data is subject to digital averaging during each sweep, and the results are displayed. The default value for the number of averaging operations is 128. If, for example, the average count display appearing on the screen is “AVG 80/128”, the data displayed represents the results after averaging has been executed represents the results after averaging has been executed 80 times out of 128. Averaging counts of 2, 4, 8, 16, 32, 64, and 128 can set by ten key operation, and the averaging is started by pressing the  key.
7.		The DISPLAY LINE appears on the screen, and the data obtained by subtracting memory A contents from memory B contents is stored in memory C as well as being displayed on the screen.
⑧		As in the above step, the data obtained by subtracting memory A contents from the input waveform (INPUT) is stored in memory C as well as being displayed on the screen.
9)		The memory A contents are inter-exchanged with the memory B contents with the new memory A contents being displayed on the screen.
10		The memory D contents are copied into memory A, and the memory A contents are then displayed on the screen.

POSI-NEGA-PEAK mode is set as the default sampling mode. (See Figure 2-5.)

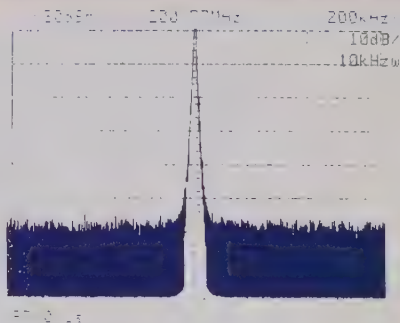


Fig. 2-5 POSI-NEGA-PEAK mode

Key pressed



Screen display and results

POSI PEAK mode is set. (See Figure 2-6.)

The mode is returned to POSI-NEGA-PEAK mode if this key is pressed a second time.

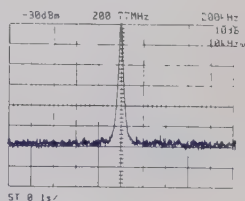


Fig. 2-6 POSI PEAK mode



A/D converter sampling mode is set to random sampling mode. (See Figure 2-7.)

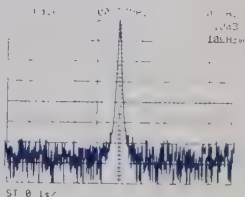
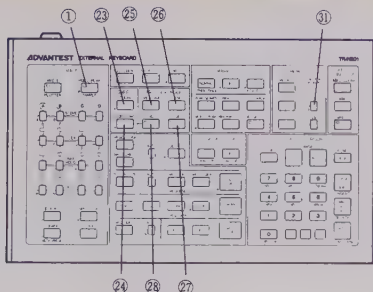


Fig. 2-7 Random sampling mode



2.5 Setting Trigger Conditions (TRIGGER and SWEEP Sections)

Key No.	Key pressed	Screen display and results
25	FREE RUN	Sweeping at the set cycle rate.
26	LINE	Sweep synchronized with the power line frequency.
27	VIDEO	Sweep started by amplitude of input signal in the same way as in oscilloscopes.
28	SINGLE	Sweep as designated by STOP/START operations.
23	CLEAR	Sweeping is reset and the input waveform display is cleared. Memory A thru D contents remain unchanged.
24	STOP/START	Sweeping stopped when trigger mode is not set to SINGLE. Sweeping is resumed from the stopped position when this key is pressed a second time. When trigger mode is set to SINGLE, repeated stopping and starting of sweeping is possible.

2.6 Memory Functions (MEMORY Section)

The various keyboard set conditions can be stored in memory and reproduced when needed. Note, however, that labels, markers, waveforms, and the DISPLAY LINE cannot be saved. Also note that the recalled data will not be accurate if the frequency and level of the measuring equipment is not calibrated.

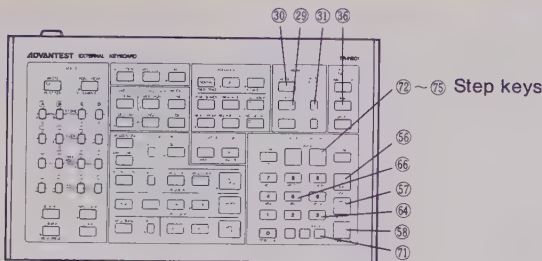
(1) SAVE

Step	Key No.	Key pressed	Screen display and results
1	29		"SAVE" is displayed. There are 12 memories. Select a value from 1 to 12 by ten key operation.
2	31		The titles of memories 1 thru 12 are listed up on the screen. Suitable titles can be written by using the label function described in the next section.
3	64		In this case, memory 3 is selected, and "SAVE 3" is displayed.
4	58		The SAVE operation is commenced (and takes about 1.5 seconds to complete).

(2) RECALL

Step	Key No.	Key pressed	Screen display and results
1	30		"RECALL" is displayed. Select the number of the memory to be recalled by using the ten keys.
2	66		Memory 5 is selected in this case, and "RECALL 5" is displayed.
3	58		The RECALL operation is commenced, and can take from 2 to 12 seconds to complete. During this period, the recalled measuring conditions are displayed on the screen.

- Do not press any keys during SAVE and RECALL operations.

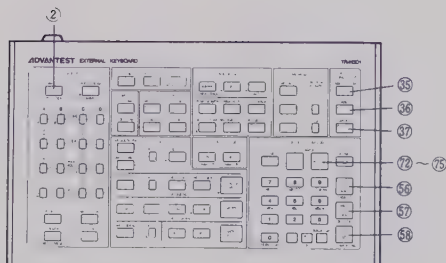


2.7 Label Function

Any desired comment can be written on the screen.

Step	Key No.	Key pressed	Screen display and results
1	36		The cursor appears on the screen, and the green character inscribed at the bottom left hand corner of each key can be keyed in. A maximum of 33 characters of comment can be included on each line.
2	72 ~ 75		Cursor movement by one character.
3	56		A single character space is inserted at the cursor position, and the character at the right hand end of the line disappears.
4	57		The character at the cursor position is deleted, and the line is justified by one character.
	71		The character at the cursor position is deleted, and the cursor is moved back by one character.

Step	Key No.	Key pressed	Screen display and results
5	(58)		All characters on the line to the right of the cursor are deleted. To clear an entire line, first move the cursor to the left hand end of the line before pressing this key.
6	(36)		The label function is cancelled when this key is pressed a second time.
7	(35)		All characters written by the label function are cleared from the screen.



2.8 Plotter Output

The **TR4133** series analyzers can be connected via GPIB to ADVANTEST's X-Y plotters **TR9831** and **TR9834R** (or equivalent equipment) to enable hard copy of screen displays to be taken.

Step	Key No.	Key pressed	Screen display and results
1			Connect the TR4133 series analyzer to a plotter via GPIB cable.
2	(37) (2)	 	The plotter menu shown in Figure 2-8 is displayed on the screen. Key in the appropriate inputs by ten keys.
PLOTTER MODE MODE SELECTION 0:ALL 1:WAVE ONLY 2:SAVED LIST 3:ADVANCED FUNCTION LIST 9:QUIT CHOSEN:0 TYPE 0:0=TR, 1=HP PAPER FEED 0:0=OFF, 1=ON SIZE GHz=LARGE MHz=MIDDLE kHz=SMALL			
3	(74) (75)	 	The cursor is shifted to the input position where 0 is displayed on the screen.
4	(56) ~ 58	  	Press one of these keys to specify the plotting area size. Plotting is commenced as soon as the key is pressed.

Fig. 2-8 Plotter menu

2.9 Advanced Function

One of the expanded functions of the **TR41301** Keyboard is the advanced function outlined below in Table 2-6. This list can be displayed on the screen by pressing  (KEY **33**), and cleared again by pressing a second time.



Table 2-6 Advanced function

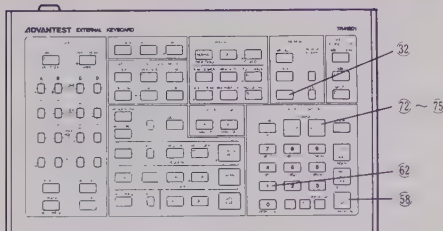
Screen display	Function
ADVANCED FUNCTION CONTENTS 10: NEXT PEAK 2 2X: OBW 3X: ADJ LEAK 40: SA*AFC 50: SAME LEVEL MK 60: ADJ PK	Marker frequency next peak search Occupied frequency bandwidth Adjacent channel leakage power measurement AFC for SWEEP ADAPTER SAME LEVEL marker Adjacent peak search

—0: Denotes that the ROM for this function is executed.

—X: Denotes that the ROM for this function is not executed.

—Function number

Step	Key No.	Key pressed	Screen display and results
1	32		"FUNCT" is displayed to indicate that the analyzer has been switched to advanced function mode.
2	62 ~ 67	 	Select required function by ten key operation.
3	58		The analyzer is switched to the selected function operation mode.

**(1) NEXT PEAK 2**

The function shifts the marker sequentially to level peaks which are higher than the operator-set DISPLAY LINE.

Step	Key No.	Key pressed	Screen display and results
1			Set the DISPLAY LINE to any desired position on the screen.
2	32 62	 	NEXT PEAK 2 mode is selected.
3	58		NEXT PEAK 2 mode is set.
4	74		The marker is shifted level peaks higher than the DISPLAY LINE in sequence from left to right.
	75		The marker is shifted to the same peaks, but in sequence from right to left. When the marker reaches the side of the screen, only a buzzer is activated. The marker moves no further.

(2) Occupied frequency bandwidth measurement

The frequency of the highest level signal within a spread of power signals in a certain frequency band is measured as the reference frequency, and the occupied frequency bandwidth (defined as the bandwidth containing 99% of the power) is computed. Due to the memory capacity, this function cannot be used when trace mode is set in "averaging". And when the marker is on, the signal where the marker serves as the reference must be traced.

Step	Key No.	Key pressed	Screen display and results
1			Check that trace mode has not been set to AVG.
2	37, 68	  10dB/DIV	Set the vertical axis scale to 10 dB/div.
3	(45) (72) ~ (74)	   	The signal to be measured is shifted to the center of the screen.
4	32, 63, 58	  	The occupied bandwidth operations are executed (in about 1 second). The buzzer is activated, and two markers appear indicating both sides of the occupied frequency bandwidth. And the occupied frequency bandwidth itself is indicated by the delta Δ marker. Note that correct data might not be obtained if the resolution bandwidth is not less than 1/20 of the SPAN/DIV.

(3) Adjacent channel leakage power measurement

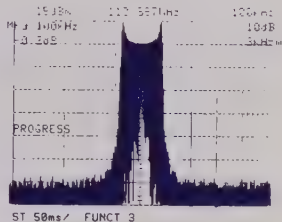
The ratio of the power of the frequency bandwidth set as desired by Δ marker centered about each point on the frequency axis (701 points) to the total power at each point is calculated at each point for waveform data stored in memory A. The results are then stored in memory C in dB units as well as being displayed on the screen.

Step	Key No.	Key pressed	Screen display and results
1	37, 68	  10dB/DIV	Set the vertical axis scale to 10 dB/div.

2 (65)      The frequency band contained the signal to be measured is displayed on the screen.

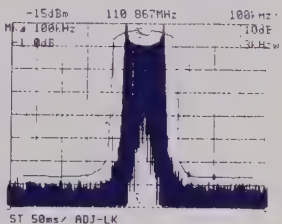
3 (13)  Set Δ marker.

4 (31) (64) (58)    Commence computation of the adjacent channel leakage power. An example of a waveform being computed is shown in Figure 2-9(a).



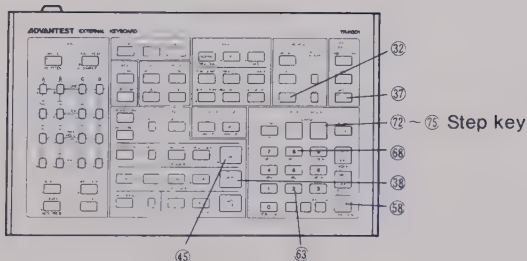
(a)

After completion of the computation, the results (see Figure 2-9(b)) are stored in memory C.



(b)

Fig. 2-9 Adjacent channel leakage power measurement



(4) SWEEP ADAPTER AFC

This function is used together with the **TR13211** Sweep Adapter designed for use with the **TR4133** Series Spectrum Analyzers. Refer to the **TR13211** Instruction Manual for details on using the adapter.

Step	Key No.	Key pressed	Screen display and results
1			Set the TR13211 Sweep Adapter.
2	(32) 65 (58)	  	Set SWEEP ADAPTER AFC mode.
3	Odd-numbered ten key		AFC-ON irrespective of SPAN/DIV.
	Even-numbered ten key		AFC-OFF irrespective of SPAN/DIV.

(5) SAME LEVEL MARKER

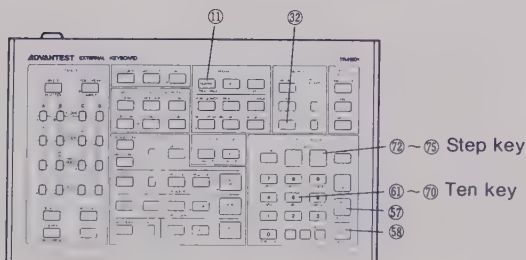
After storing a particular level in memory, a search is made for signal peaks of the same level.

Step	Key No.	Key pressed	Screen display and results
1	(11) (72) ~ (75)	   	The marker is displayed, and moved to the position of the level to be sought.
2	(32) (66) (58)	  	SAME LEVEL MARKER mode is set, and the "SMLVMK" indicator appear on the screen. The marker level at this time is stored in memory as the search reference level.
	(74)		Waveform peaks at the same level as the stored level are sought for from the low frequency end (left hand side of screen).
	(71)		The same search is made from the right hand side.

(6) Adjacent peak search

Any desired frequency band is specified by the number of points, and the marker is moved to the highest peak within the bandwidth.

Step	Key No.	Key pressed	Screen display and results
1	(11)	NORMAL	Marker is turned on.
2	(32) 67 58	f 8 kHz dB	Adjacent peak search mode is set. The range in which the adjacent peak search is to be executed is specified by a desired number of points. The interval between screen grid scale lines consists of 70 points.
3		1 4 0 GHz V sec	For example, to search one scale interval on both sides of the marker, specify $70 \times 2 = 140$ points.
	(58)	kHz dB	The adjacent peak search function is started.
3'	(57)	MHz mV ms	It is also possible to set the interval between the marker and the edge of the screen as the search range.
This function is cancelled if any other function (such as CENTER FREQ) is set.			



3. Measuring Examples

All of the following examples assume that the **TR4133** Series Spectrum Analyzer has been warmed up for at least 30 minutes and has been set to the default values.

3.1 Frequency Measurements

Frequencies can be measured by either setting the target frequency to the center frequency and reading the indicated data, or by adjusting a marker to the target frequency and then reading the marker frequency. The method described here is the marker frequency method. The frequency error in the first local oscillator in the **TR4133** series analyzer is ± 20 MHz. And since the center frequency accuracy exceeds ± 20 MHz when SPAN/DIV is less than 100 MHz/div, the frequency must be calibrated to correct the error when measuring under these conditions. This frequency calibration can be executed automatically by leaving the

TR4133 series analyzer INPUT connector open and pressing the **TR4133** 

and  keys. Once the analyzer has been calibrated in this way, the input signal to be measured can be applied to the analyzer to commence the measurement.

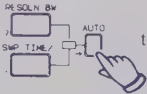
Step 1 Press  to sweep the entire bandwidth from 0 to 3.6 GHz.

Step 2 Align the marker to the highest level of the signal to be measured.



Use the PEAK SEARCH function if the signal to be measured is the highest level on the screen.

Step 3 The following steps up to step (6) describe how to gradually narrow the frequency span while keeping the signal to be measured in the center of the screen, thereby improving the accuracy of the measurement.

Press  to set the optimum sweep time and resolution bandwidth for the set SPAN/DIV.

Step 4 Press  to align the target measured in the center of the screen.

Step 5    SPAN/DIV is set to 5 MHz. Each time SPAN/DIV is narrowed, the target signal is displaced from the center of the screen. Correct this position each time by repeating steps (2) and (4).

Step 6   

Step 7

Step 8 Set the marker to the signal peak by using the keys.

Step 9 The center frequency displayed at this stage is the frequency to be measured. The accuracy is $\pm (1 \text{ MHz} + 400 \text{ kHz})$, that is, $\pm 1.4 \text{ MHz}$. (See Figure 3-1.)

The frequency accuracy can be further improved in the following way.

Step 10 Further reduce the frequency span.

Step 11 Align the marker with the signal peak.

Step 12

Step 13

Step 14

Step 15 Align the marker with the signal peak.

Step 16

The center frequency displayed at this stage is the frequency to be measured. The accuracy is $+10 \text{ kHz} \times N$ (where N is the number of harmonics.) (See Figure 3-2.)

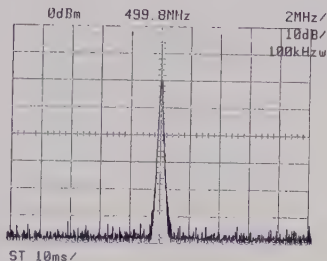


Fig. 3-1 Measurement at 2 MHz/division

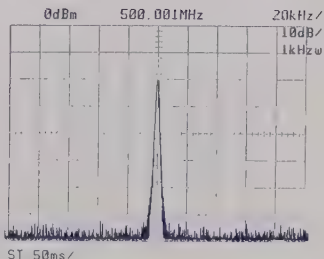


Fig. 3-2 Measurement at 20 kHz/division

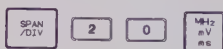
3.2 Level Measurement

When a level is to be measured, the amplitude must first be calibrated by using the **TR4133** series analyzer calibration signal (200 MHz, -30 dBm).

Amplitude calibration procedure

Step 1 Connect the **TR4133** CAL OUT connector to the INPUT connector using the MC-06 connecting cable and N-BNC conversion adapter provided. (See Figure 3-3.)

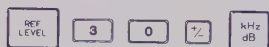
Step 2 Set SPAN/DIV to 20 MHz.



Step 3 Set the center frequency to the calibration signal frequency of 200 MHz.



Step 4 Likewise, set the reference level to -30 dBm



Step 5 Adjust the marker to the peak of calibration signal.



Step 6 Turn the **TR4133** AMPTD CAL control to adjust the marker level display to -30.0 dBm. (See Figure 3-3.) This completes the amplitude calibration.

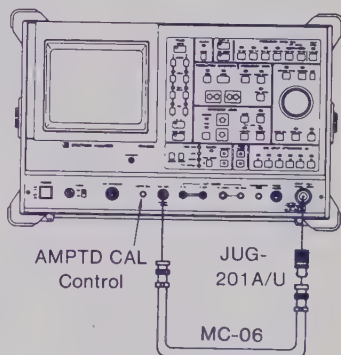
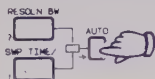


Fig. 3-3 Set up for amplitude calibration

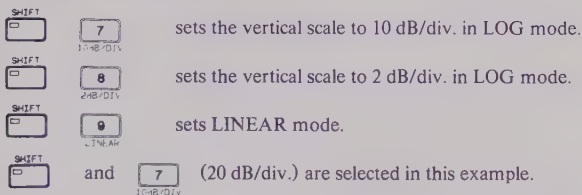
Level measurement

Step 1 Apply the input signal to be measured.

Step 2 Set resolution bandwidth and sweep time to AUTO.



Step 3 The level display can be selected as LOG or LINEAR.



Step 4 Set the frequency span to a suitable value.



Step 5 Set the frequency of the signal being measured (675 MHz for example) to the center frequency.



Step 6 Adjust the marker to the signal being measured.



Read the measured signal level from the marker level display.

The following level units are selected in LOG mode.

dBm is selected by  , 

dBμ is selected by  , 

dBpW is selected by  , 

Step 7 The maximum measuring error in this case is estimated as follows.

Maximum measuring error = Frequency response $\pm$ Return loss error ± 4.7 dB

Where the level measuring accuracy is considered on the basis of the above expression, the IF substitute method is to be used. Refer to the **TR4133** Series Spectrum Analyzer Instruction Manual for details on the IF substitution method and maximum measuring error.

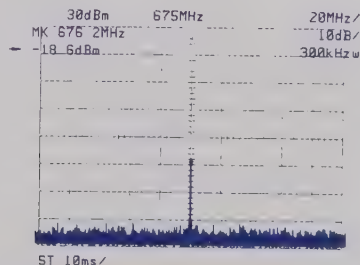


Fig. 3-4 Level measurement

3.3 Distortion Measurements

The distortion in a 900 MHz band transmitter is measured here as an example.

- Step 1 Connect a transmitter, RF coupler, and **TR14101** high-pass filter as shown in Figure 3-5. Since the maximum input level which can be applied to the **TR4133** is +20 dBm with an input attenuator of at least 20 dB, the RF coupler output value must be set to a value not in excess of +20 dBm.

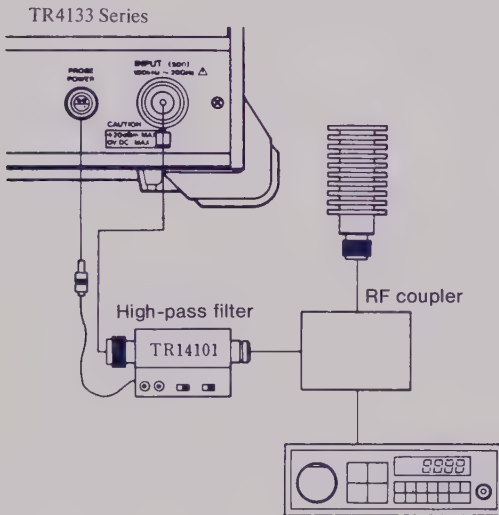


Fig. 3-5 Distortion measurement set up example

Step 2 Set the **TR14101** high-pass filter FLTR/THRU switch to the THRU position.

Step 3 Set the **TR4133** MIN INPUT ATTENUATOR to a value which ensures that the signal mixer input level (signal level – input attenuator value) is less than –10 dBm. That is, if the signal level is +15 dBm, adjust MIN INPUT ATTENUATOR to 30 dB.



Step 4



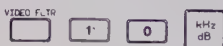
Step 5



Step 6



Step 7



Step 8



Step 9



Step 10



Step 11 Change the **TR14101** high-pass filter FLTR/THRU switch to the FLTR position.

Lower the ATTenuator if the harmonics level is low.

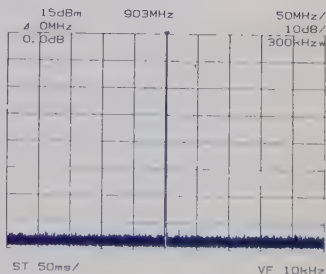


Fig. 3-6 Fundamental wave level measurement

Step 12 When is pressed, the Δ marker display shows the ratio of the second harmonic to the fundamental wave in dB. And when the **TR14101** calibration value of 1 dB is added, a value of -95.0 dB is obtained. (See Figure 3-7.)

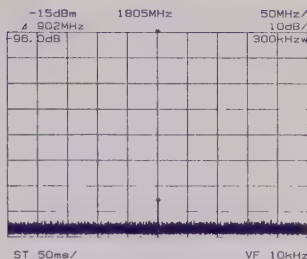


Fig. 3-7 Second harmonic level measurement

Step 13

Step 14 When is pressed in the case, the ratio of the third harmonic to the fundamental wave is shown in dB. The value obtained in this case is -97.8 dB. (See Figure 3-8.)

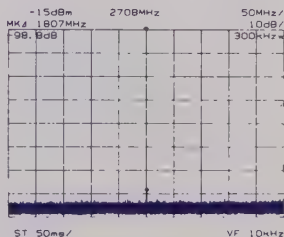


Fig. 3-8 Third harmonic level measurement

3.4 Measurement of AM Signal Modulation Frequency and Modulation Index

AM signals are measured in ZERO SPAN mode when the modulation frequency is low and the modulation level is high. If the modulation frequency is high and the modulation level low, however, the horizontal axis is usually set to frequency span mode, and the differences between the sideband frequency / level and the carrier wave frequency / level are determined. Higher measuring accuracy is attained when measurements are conducted in LINEAR mode if the modulation index is above 10%, and in LOG mode if below 10%.

The respective measuring procedures for low and high modulation frequencies are outlined below.

3.4.1 AM Signal Measurement when Modulation Frequency is Low and Modulation Index High

Step 1 Connect the AM transmitter output to the spectrum analyzer INPUT connector via an external attenuator if necessary. (See Figure 3-9.)

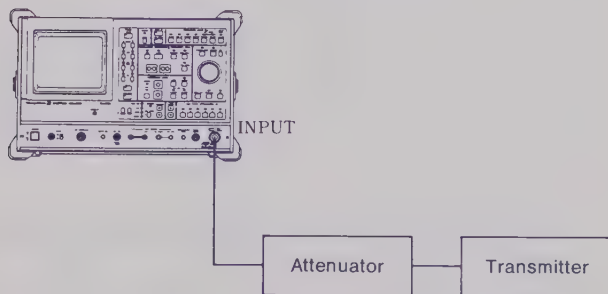


Fig. 3-9 Set-up for measuring modulation signals

Step 2 Set the center frequency to the AM signal frequency.



- Step 3 Set the resolution bandwidth to a value at least three times as great as the modulation frequency.



- Step 4 Adjust the marker to the peak of the signal being measured.



- Step 5 Adjust the peak of the measured signal to the reference level.



- Step 6 Set the vertical scale to LINEAR.



- Step 7 Set to ZERO SPAN mode.



- Step 8 Adjust the center frequency to obtain maximum level.



- Step 9 Set TRIGGER MODE to VIDEO.



- Step 10 Set the sweep time to a value which permits easy measurement.



Step 11 Adjust the marker to the signal peak.



Step 12 Adjust the Δ marker to the next signal peak (see Figure 3-10.)



Step 13 In this example, one cycle from the Δ marker is measured at 10.0 ms. The modulation frequency f_m , therefore, is determined from the following.

$$f_m = \frac{1}{t_m} = \frac{1}{10.0(\text{ms})} = 100(\text{MHz})$$

Step 14 Adjust the marker to the signal peak and read the level E_{max} .



Step 15 Adjust the marker to the minimum value in the waveform and read the level E_{min} . The modulation index m is calculated from the following expression.

$$m = \frac{E_{\text{max}} - E_{\text{min}}}{E_{\text{max}} + E_{\text{min}}}$$

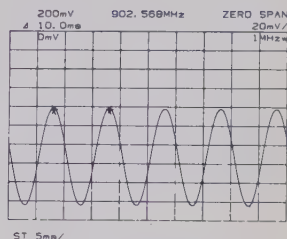
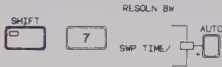


Fig. 3-10 Reading modulation frequencies

3.4.2 Measuring AM Signals of High Modulation Frequency, and AM Signals of Low Modulation Index

- Step 1 Connect the AM transmitter output to the spectrum analyzer INPUT connector via an external attenuator if necessary.
- Step 2 Set the vertical axis scale to 10 dB, and the resolution bandwidth and sweep time settings to automatic setting mode.



- Step 3 Set the frequency span below the modulation frequency.



- Step 4 Set the center frequency to the carrier frequency.



- Step 5 Press  if a waveform appears on the screen.

- Step 6 Adjust the marker to the carrier wave peak.



- Step 7 Set the peak where the marker is located to the center frequency.



- Step 8 Set the peak where the marker is located to the reference level.

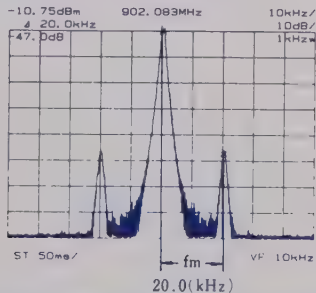


Fig. 3-11 Read the difference in frequency of carrier and sideband signal

Step 9 Adjust the Δ marker to the sideband signal peak.

The modulation frequency f_m and modulation index m can then be calculated from the displayed Δ marker frequency and level by using the following equations.

$$f_m = \Delta \text{marker frequency}$$

$$m = \log^{-1} \frac{(E_{SB} - E_c + 6)}{20} \times 100(\%) = \log^{-1} \frac{(\Delta \text{ marker level} + 6)}{20} \times 100(\%)$$

Example: $f_m = 20.0 \text{ kHz}$

$$m = \log^{-1} \frac{-47+6}{20} \times 100 = 0.89(\%)$$

The relationship between the modulation index m and the value obtained by subtracting the carrier wave level E_c from the sideband level E_{SB} is shown in Figure 3-12.

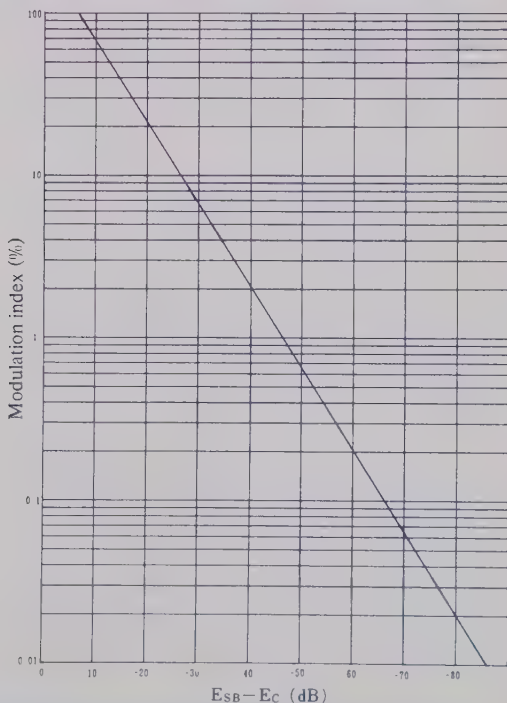


Fig. 3-12 Relationship between the modulation index m and the value obtained by subtracting the carrier wave level E_c from the sideband level E_{SB}

3.5 FM Signal Measurement

When measuring FM signals, the modulation frequency f_m , modulation index m , and peak deviation Δf_{peak} can be determined.

When the modulation frequency is low, the horizontal axis is set to ZERO SPAN to operate the analyzer as a fixed tuned receiver where frequency is modulated by using the slope of an IF filter, and the signal then measured on the time axis. Where the modulation frequency is high, signals are measured on the frequency axis, and the modulation frequency is found from the sideband frequency. Measuring examples are outlined below.

3.5.1 Measuring FM Signals with Low Modulation Frequency

Step 1 Adjust the signal carrier wave to the center frequency.



Step 2 Set the frequency span to a value which permits easy observation of the waveform.



Step 3 Adjust the marker to the signal peak.



Step 4 Move the carrier wave to the center of the screen, and adjust the peak to the reference level.



Step 5 Lower the reference level and adjust the signal peak to a position 10 dB (one grid scale) above the top reference level on the horizontal axis.

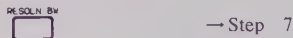
Step 6 Set to ZERO SPAN mode.



Step 7 Adjust the demodulated wave peak to the reference level.



Step 8 With the resolution bandwidth set to a value at least three times greater than the modulation frequency, adjust the demodulated wave so that it can be easily observed on the screen.



Step 9 Set TRIGGER MODE to VIDEO.



Step 10 Set the sweep time to a value which permits easy observation of the waveform.



Step 11 Adjust the marker to the demodulated wave peak.



Step 12 Adjust the Δ marker (see Figure 3-13.)



The modulation frequency f_m is measured as

$$f_m = \frac{1}{T(s)} \text{ from the time interval } T(s) \text{ between the } \Delta \text{ markers.}$$

$$\text{Example: } f_m = \frac{1}{10.3 \text{ (ms)}} = 97.1 \text{ (Hz)}$$

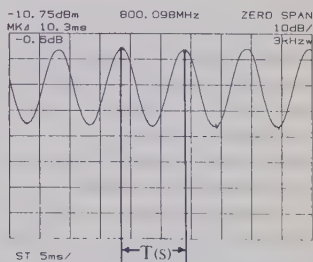


Fig. 3-13 Determination of demodulated wave time interval $T(s)$

3.5.2 Measuring FM Signals with High Modulation Frequency

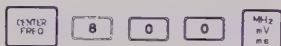
- Step 1 Set the vertical axis scale to 10 dB, and the resolution bandwidth and sweep time settings to automatic setting mode.



- Step 2 Set the frequency span to a value lower than the modulation frequency.



- Step 3 Adjust the carrier frequency to the center frequency.



- Step 4 Press  if a waveform appears on the screen.

- Step 5 Adjust the marker peak to the center frequency.



- Step 6 Adjust the marker peak to the reference level.



- Step 7 Adjust the Δ marker to the adjacent sideband peak. (See Figure 3-13.)



The frequency indicated by the Δ marker is the modulation frequency f_m .

Example: $f_m = 20.1$ (kHz)

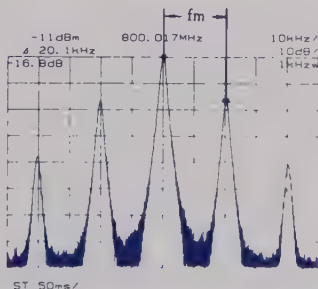


Fig. 3-14 Determination of demodulation frequency from Δ marker

3.5.3 Measurement of FM Signal Peak Deviation Δf_{peak}

Step 1 Set the resolution bandwidth to a value which includes the main sidebands (at least five times the modulation frequency).



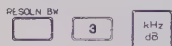
Step 2 Set the frequency span to the value to be measured after adjusting to the peak deviation.



Step 3 Set the center frequency to the signal frequency.



Step 4



Step 5



Step 6 Adjust the marker to one of the waveform peaks.

Step 7 Adjust the Δ marker to the other peak. Determine the Δf_{peak} by reading the displayed Δ marker frequency. (See Figure 3-14.)

$$\Delta f_{\text{peak}} = 1/2 \Delta f_{\text{peak Peak}}$$

Modulation index m is calculated from Δf_{peak} and f_m using the following relationship.

$$\text{Modulation index } m = \frac{\Delta f_{\text{peak}}}{f_m}$$

$$\text{Example: } \Delta f_{\text{peak}} = \frac{113.5}{2} = 56.75 \text{ (kHz)}$$

If f_m is determined as 1 kHz by the procedure of the section 3.5.2,

$$m = \frac{56.75}{1} = 56.75 \text{ (\%)}$$

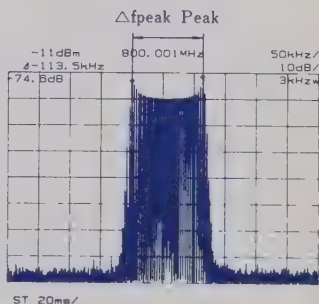


Fig. 3-15 Reading $\Delta f_{\text{peak Peak}}$

3.5.4 Determining the FM Modulation Index m When m is Small (Less than about 0.8)

The following relationship is established when the FM modulation index is less than 0.8 (approximately).

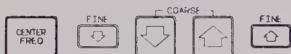
$$m = \frac{2 \times E_{SB}}{E_c}$$

Where E_{SB} is the first sideband level, and E_c is the carrier level.

Step 1 Set SPAN/DIV to a value below the modulation frequency.



Step 2 Adjust the center frequency to carrier frequency.



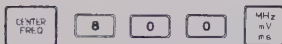
Step 3



Step 4



Step 5



Step 6



Step 7 Adjust the marker to the carrier wave peak.



Step 8 Adjust the carrier wave peak to the reference level.



Step 9 Adjust the Δ marker to the first sideband signal peak.



The modulation index m can then be calculated from the following equation if the displayed Δ marker is E (dB).

$$m = \frac{2 \times E_{SB}}{E_c}$$

$$= \log^{-1} \frac{(E_{SB} - E_c + 6)}{20}$$

$$= \log^{-1} \frac{\Delta E + 6}{20}$$

Example: $m = \log^{-1} \frac{-33.6 + 6}{20} = 4.17(\%)$

Step 10 The modulation frequency can be determined from the following relationship.

$$f_m = |f_{SB} - f_c|$$

And Δf peak is determined from the following.

$$\Delta f_{\text{peak}} = m \times f_m$$

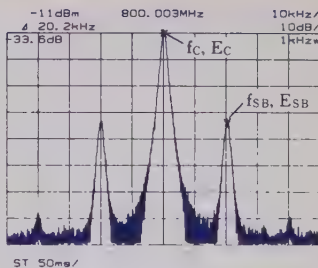


Fig. 3-16 FM modulation index measurement ($m < 0.8$)

3.6 Magnetic Field Strength Measurement

Spectrum analyzers operate on the same theory as magnetic field strength measuring devices. The following example outlines how the magnetic field strength can be measured using a **TR4133** series spectrum analyzer and a dipole antenna.

Step 1 Connect the antenna to the INPUT connector ($50\ \Omega$) of the **TR4133** analyzer. If the antenna impedance is not $50\ \Omega$, use a matching circuit resistance to ensure that the impedance is matched.

Step 2 Set a center frequency and the frequency span, etc. to proper value.



Step 3 Switch the reference level unit to $\text{dB}\mu$



Step 4 Adjust the marker to the signal to be measured.



Step 5 Read the displayed marker level as $\text{ex}(\text{dB}\mu)$.

$$\text{ex} = \text{Ex} + \text{He} - \text{La} - \text{Ba}, \text{ and}$$

$$\text{Ex} = \text{ex} + \text{La} - \text{He} + \text{Ba}$$

$$= \text{ex} + \text{K}$$

where

$\text{Ex}(\text{dB})$: Magnetic field strength ($1\ \mu\text{V/m} = 0\ \text{dB}\mu$)

$\text{He}(\text{dB})$: Effective length of dipole antenna ($1\ \text{m} = 0\ \text{dB}$)

$\text{La}(\text{dB})$: Cable loss

$\text{Ba}(\text{dB})$: Balun loss

$\text{K}(\text{dB})$: Calibration coefficient

The relationship between frequency and the calibration coefficient is shown in Figure 3-17.

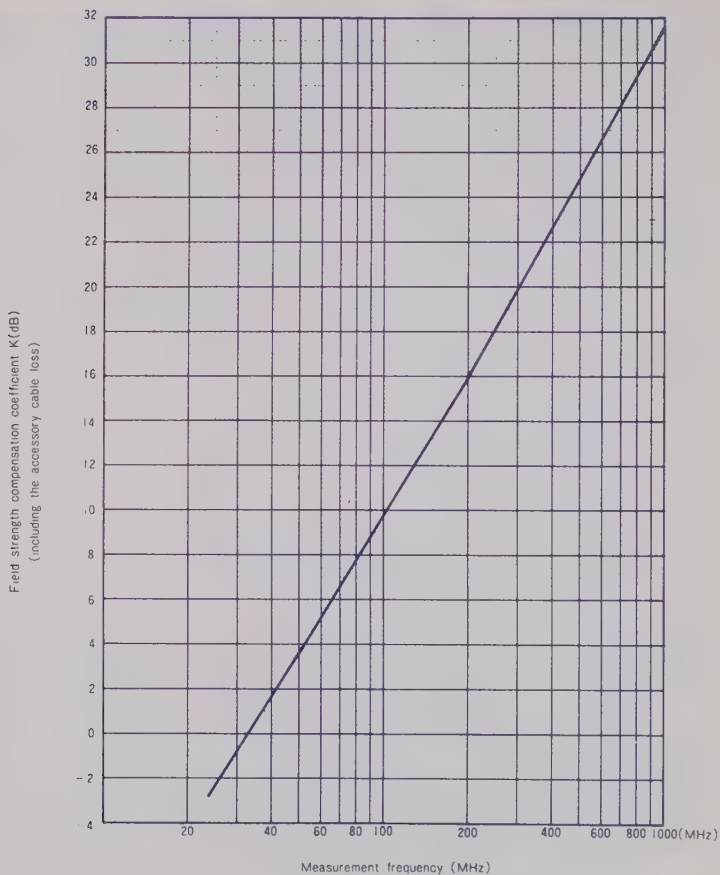


Fig. 3-17 Relationship between frequency and the calibration coefficient in magnetic field strength measurements

3.7 Measurement of Pulse Modulated Signals

The following parameters can be readily measured when measuring pulse modulated signals such as radar.

- (1) Pulse repetition frequency (PRF)
- (2) Pulse width (τ)
- (3) Carrier frequency (f_c)
- (4) Peak power (P_{peak}) and average power (P_{ave})

CAUTION

The maximum input level which can be handled by the TR4133 is $+20$ dBm, 0 Vdc with MIN INPUT ATTENUATOR adjusted to at least 20 dB. Because of the high peak power in pulse modulated signals such as radar, the level must first be adequately reduced by coupler etc before being applied to the INPUT connector.

And since the series mixer input level is -10 dBm, set MIN INPUT ATTENUATOR to a value which ensures that $P_{\text{peak}} \leq -10$ dBm. To avoid mixer saturation, lower MIN INPUT ATTENUATOR in 10 dB steps from 50 dB to find the minimum attenuator value where the signal level shows no further decrease.

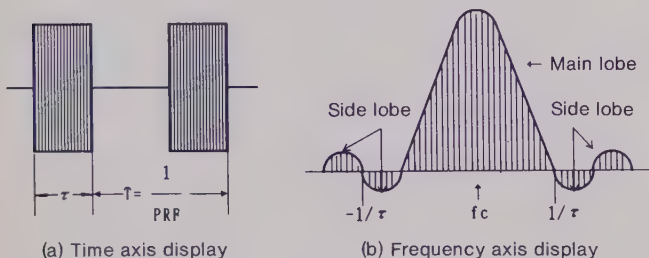


Fig. 3-18 Pulse modulated signal

3.7.1 Pulse Repetition Frequency (PRF) Measurement

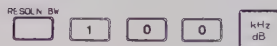
Step 1 Set the trace mode to POSI PEAK.



Step 2 Set the frequency span to a suitable value.



Step 3 Set the resolution bandwidth to a value sufficiently wider than the pulse repetition frequency.



Step 4 Set the center frequency to the carrier frequency.



Step 5 Set the frequency span to ZERO SPAN.



Step 6 Set the trigger mode to SINGLE and execute a single sweep.



Step 7 Set the marker to one of the peaks.



- Step 8 Adjust the Δ marker to an adjacent peak.



The pulse repetition frequency (PRF) can be found from the following relationship.

$$\text{PRF} = \frac{1}{T(\text{ms})} \text{ (kHz)}$$

where $T(\text{ms})$ is time interval between the markers.

Example: $\text{PRF} = \frac{1}{4.4} = 227.31 \text{ (kHz)}$

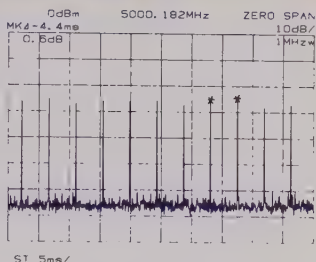


Fig. 3-19 Determination of the pulse modulation frequency on the time axis

3.7.2 Measurement of Pulse Width τ and Carrier Frequency f_c

The pulse width τ can be determined from the inverse of half the main lobe width, or from the inverse of a side lobe width. In this case, the resolution bandwidth must be set within the following range to obtain an envelope with adequate resolution.

$$\text{PRF} \times 1.7 \leq \text{Resolution bandwidth} \leq 0.1/\tau$$

Steps (1) thru (8) are identical to steps (1) thru (8) of the previous procedure (3.7.1).

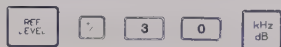
- Step 9 Set the trigger mode to FREE RUN.



- Step 10 Adjust SPAN/DIV to obtain a clearly defined main lobe.



- Step 11 Adjust the reference level to a value where the signal is easy to observe.



Step 12 Set the sweep time to at least 70/PRF (s/div.).



Step 13 Reading of f_c

Adjust the marker to the center of the main lobe.

The marker frequency will then correspond to the carrier frequency f_c . The f_c measuring accuracy is determined by the pulse width τ .

If r is small, the main lobe is wide and the center is hard to determine. To obtain a clearer display of the center, SPAN/DIV must be set to a value wider than $1/\tau$.

The measuring accuracy in this case is the same as the center frequency accuracy at the selected SPAN/DIV.

Step 14 Adjust the marker to the lowest level of the main lobe.



Step 15 Adjust the Δ marker to the lowest level of an adjacent side lobe. (See Figure 3-20.)

If f represents the Δ marker display, the width τ can be determined from $\tau = 1/\Delta f$.

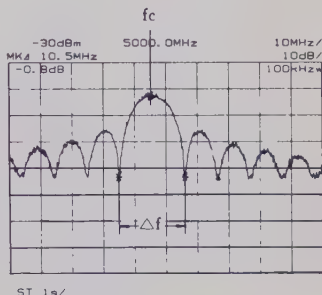


Fig. 3-20 Measurement of τ

$$\text{Example: } \tau = \frac{1}{10.5 \times 100} = 0.095 \text{ } (\mu\text{s})$$

3.7.3 Measurement of Peak Power (P_{peak}) and Average Power (P_{ave})

The amplitude display is proportional to the resolution bandwidth of the spectrum analyzer if that bandwidth satisfies the following condition.

$$\text{Pulse repetition frequency (PRF)} \times 1.7 \leq \text{Resolution bandwidth} \leq 0.2/\tau$$

In this case, the amplitude display is proportional to the resolution bandwidth, and the relationship between the actual peak power P_{peak} (dBm) and the amplitude display P'_{peak} (dBm) is as follows.

$$P_{\text{peak}} = P'_{\text{peak}} + a \text{ (dB)}$$

$$a \text{ (dB)} = 20 \log (\tau \times 1.5 \times \text{RBW})$$

where a is called the pulse attenuation rate. The average power P_{ave} (dBm) is calculated from the following.

$$P_{\text{ave}} = P_{\text{peak}} \times \text{PRF} \times \tau$$

where PRF is the pulse repetition frequency (Hz) and τ is the pulse width (s)

4. GPIB Programming

The standard functions of the **TR4133** series Spectrum Analyzer and the functions enabled by the **TR41301** External Keyboard can be controlled external via GPIB. Refer to the instruction manuals for further details on its features and handling procedures.
The GPIB programming codes are listed below.

4.1 Command Codes

Commands indicated by *1, *2, or *3 to the right of the command name are restricted in use.

- *1: This command cannot be programmed with another command on the same line. If followed by another command on the same line, the second command is ignored.
- *2: This command is ignored if followed by another command under certain conditions. Either program the next command on a new line, or program each command as described in the instruction manuals.
- *3: Restrictions in numerical setting of marker and display line. Program as described in the instruction manuals.

Setting precautions for other commands such as those which take time to be executed are described in the instruction manuals.

Table 4-1 Functions executed only by TR4133/A/B analyzer key input

Code	Corresponding key	Code	Corresponding key
A0	MIN INPUT ATTENUATOR 0dB	Y0	TUNING knob turned counter clockwise
A1	MIN INPUT ATTENUATOR 10dB	Y1	TUNING knob turned clockwise
A2	MIN INPUT ATTENUATOR 20dB	FB	SPAN/DIV
A3	MIN INPUT ATTENUATOR 30dB	BW	RBW
A4	MIN INPUT ATTENUATOR 40dB	NR	
A5	MIN INPUT ATTENUATOR 50dB	WD	
Frequency bands, enclosed in parentheses are the TR4133/A/B frequencies. The unit is GHz.		FC	(REFL. LEVEL UP, DOWN) FINE COARSE
B0	0~3.6 (0~3.6)	LD	(REFL. LEVEL) DOWN
B1	0.01~4 (3.5~7.5)	LU	(REFL. LEVEL) UP
B2	4~12 (7.2~15.2)	UN	(REFL. LEVEL) UNITS
B3	8~12 (10.9~20)	LC	(GPIB) LOCAL
B4	12~20 (18~28)	TR	TRIGGER MODE DOWN
B5	18~28 (28~60)	SR	(SWEEP) START
B6	28~60 (MULTI BAND 3.5~20)	TU	(SWEEP TIME) UP
		TD	(SWEEP TIME) DOWN
FA*2	CENTER FREQ	VU	(VIDEO FILTER) UP
M1*1	MARKER	VD	(VIDEO FILTER) DOWN

Table 4-2 Functions common to both TR41301 External Keyboard and TR4133 Series Spectrum Analyzer

Code	Corresponding key
WR* ¹	WRITE
SA* ¹	STORE A
SB* ¹	STORE B
VWA* ¹	VIEW A
VWB* ¹	VIEW B
MA* ¹	MAX HOLD A
MB* ¹	MAX HOLD B
AA _n * ¹	AVG A
AB _n * ¹	AVG B Note: n is the number of averaging operations set.
SU* ¹	B-A
PP	POSI PEAK
SG	SIG IDENT

Code	Corresponding key
S1	SHIFT IF
BA	RBW AUTO
MO	MARKER OFF
FL* ¹	FREQ CAL
ZL* ¹	ZERO CAL
ZS	ZERO SPAN
FS	FULL SPAN
AF	AFC
CL	CLEAR
L1	Vertical axis scale: 10 dB/div.
L2	Vertical axis scale: 2 dB/div.
LN	Vertical axis scale: Linear (V)

Table 4-3 Functions available only with the TR41301Keyboard

Code	Corresponding key	Code	Corresponding key
SC* ¹	STORE C	AT	ATT
SD* ¹	STORE D	LO	LEVEL OFFSET
VWD* ¹	VIEW C	FU	FINE UP
VWD* ¹	VIEW D	FD	FINE DOWN
MC* ¹	MAX HOLD C	CU	COARSE UP
MD* ¹	MAX HOLD D	CD	COARSE DOWN
ACn* ¹	AVG C	0	(Ten key) 0
ADn* ¹	AVG D	1	(Ten key) 1
SM	(SAMPLING MODE) SAMPLE (SHIFT)	2	(Ten key) 2
IA* ¹	INPUT-A	3	(Ten key) 3
CA* ¹	B $\leftrightarrow$ A	4	(Ten key) 4
DA* ¹	D $\leftrightarrow$ A	5	(Ten key) 5
T0	FREE RUN	6	(Ten key) 6
T1	LINE	7	(Ten key) 7
T2	VIDEO	8	(Ten key) 8
T3	SINGLE	9	(Ten key) 9
SS	SWEEP STOP/START	.	(Ten key) .
MK0* ²	MARKER $\rightarrow$ REFERENCE LEVEL	—	(Ten key) +/—
MK1* ²	FIXED Δ MARKER (SHIFT)	GZ	GHz, V, sec
M2* ^{2,3}	Δ MARKER	MZ	MHz, mV, ms
MK2* ²	NOISE/Hz	KZ	kHz, dB
M3* ³	MARKER $\rightarrow$ CENTER FREQ.	V	GHz, V, sec
MK3* ²	NEXT PEAK	MV	MHz, mV, ms
M4* ²	PEAK SEARCH	UV	No correspondence key
MK4* ^{2,3}	NORMAL MARKER	S	GHz, V, sec
M5* ²	SIG TRACK	MS	MHz, mV, ms
MK5* ²	OTHER TRACE	DB	kHz, dB
RB	RESOLN BW	DM	kHz, dB (dBm)
ST	SWP TIME/	DU* ²	kHz, dB (dB μ)
VF	VIDEO FILTER	DP	kHz, dB (dBpW)
D1* ^{2,3}	DISPLAY LINE ON	U1	(UNIT) dBm (SHIFT)
D0* ^{2,3}	DISPLAY LINE OFF	U2	(UNIT) dB μ (SHIFT)
CF	CENTER FREQ.	U3	(UNIT) dBpW (SHIFT)
FO	FREQ. LOCK	SV	SAVE
CS1	CF STEP SIZE	RC	RECALL
CS2	CF STEP SIZE AUTO	FN	f
SP	SPAN/DIV	LB1	LABEL
FT* ²	START(Frequency)	LB2	LABEL CLEAR
FP* ²	STOP(Frequency)	PL	PLOTTER
B8	FREQ BAND	C1	CHARACTER ON
B7	FREQ BAND AUTO	C0	CHARACTER OFF
RL	REF LEVEL	IP	INSTRUMENT PRESET

Table 4-4 GPIB function selector codes

Setting	Code	
Header	HD0 HD1	Header OFF Header ON
Block delimiter	DL0 DL1 DL2 DL3	"CR", "LF" + EOI "LF" EOI "CR", "LF"
Output data	OP OS OM	Output Interrogated Parameter Output Stylus Byte Output Mode String
Trace data input	IN	Input Trace Data
Service request	S0 S1	SRQ sent SRQ not sent

Table 4-5 "OP" parameter codes

Code	Output parameter
CF	CENTER FREQUENCY
IG	IF GAIN
MF	MARKER FREQUENCY
ML	MARKER LEVEL
RB	RESOLUTION BANDWIDTH
RL	REFERENCE LEVEL
SP	SPAN/DIV
ST	SWEEP TIME
VF	VIDEO FILTER

Table 4-6 Trace data designation codes

Code	Input/output data	Data type
TAA TAB TAC TAD TAW	Memory A trace data Memory B trace data Memory C trace data Memory D trace data WRITE memory trace data	ASCII codes
TBA TBB TBC TBD TBW	Memory A trace data Memory B trace data Memory C trace data Memory D trace data WRITE memory trace data	Binary codes

4.2 Output Data Format

The OP command output data formats are outlined in Table 4-7.

Table 4-7 Output data formats

Output data setting code	Format	Number of output bytes (Excluding block delimiter)
OP (Excluding trace data)	Diagram labels: HH, DDDDDDDD, DD, E±D, CRLF. Annotations: Block delimiter (CRLF), Data exponential section (E±D), Data mantissa section (DDDDDDDD), Data sign (Positive: space " ", Negative: "-") (DD), Header (see Table 4-8) (HH).	17
OP trace data	For ASCII outputs Diagram labels: DDDD, CRLF. Annotation: Block delimiter (CRLF), Trace data (for one point) (DDDD).	4
	For binary outputs Diagram labels: D D D D ~ D D D. Annotations: Upper byte 2 (D D), Lower byte 1 (D D), Upper byte 1 (D D), Lower byte 701 (D D), Upper byte 701 (D D). Note: (One byte of data in two bytes). Note: EOI is inserted in the final byte of data as the delimiter. CRLF not used.	1402
OS	Diagram labels: D D. Annotations: Status byte 2 (D), Status byte 1 (D). Note: EOI is inserted in the final byte of data as the delimiter. CRLF not used.	2

Output data setting code	Format	Number of output bytes (Excluding block delimiter)
0M	Note: EOI is inserted in the final byte of data as the delimiter. CRLF not used.	11

Since the total number of bytes in output data apart from trace data output is 17, execute the array declaration in more than 17 bytes for input of character string variables from the controller.

The header at the beginning of the output data indicates the type of data. See Table 4-8.

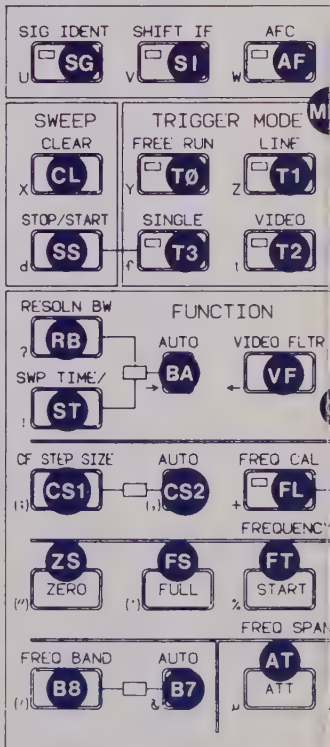
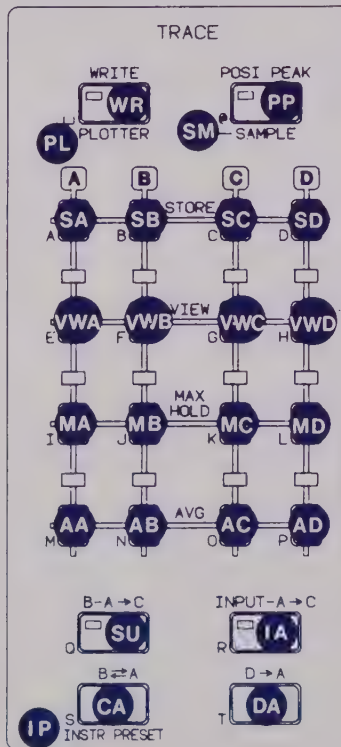
With the “HD0” command, the header is switched off and is not included in the output.

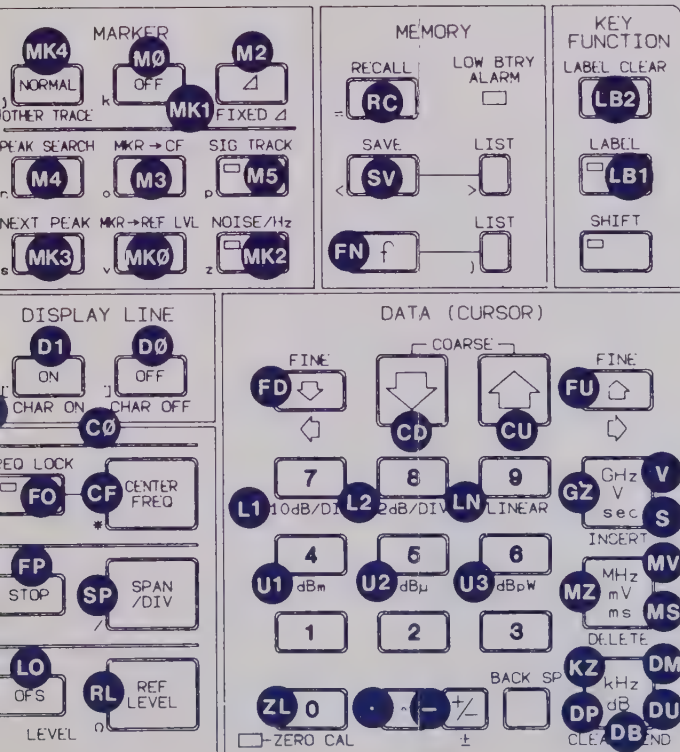
With the “HD1” command, the header is switched on and is included in the output.

Table 4-8 Relationship between output data and headers

Type of output data			Header
CENTER FREQUENCY			CF
SPAN/DIV			SP
REFERENCE LEVEL	dBm		DM
	dB μ		DU
	dBpW		DP
	LINEAR		LV
SWEEP TIME/DIV			ST
RESOLUTION BANDWIDTH			RB
VIDEO FILTER			VF
IF GAIN			IG
MARKER	FREQUENCY		MF
	LEVEL	dBm	MM
		dB μ	MU
		dBpW	MP
		LINEAR	ML

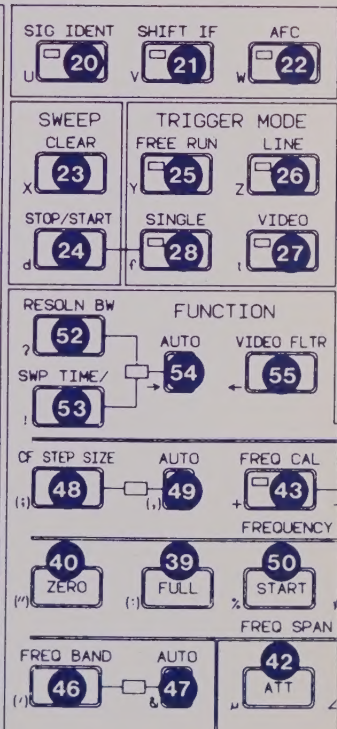
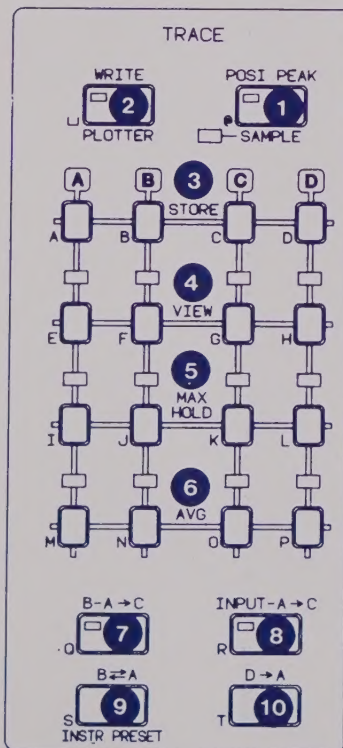
ADVANTEST EXTERNAL KEYBOARD



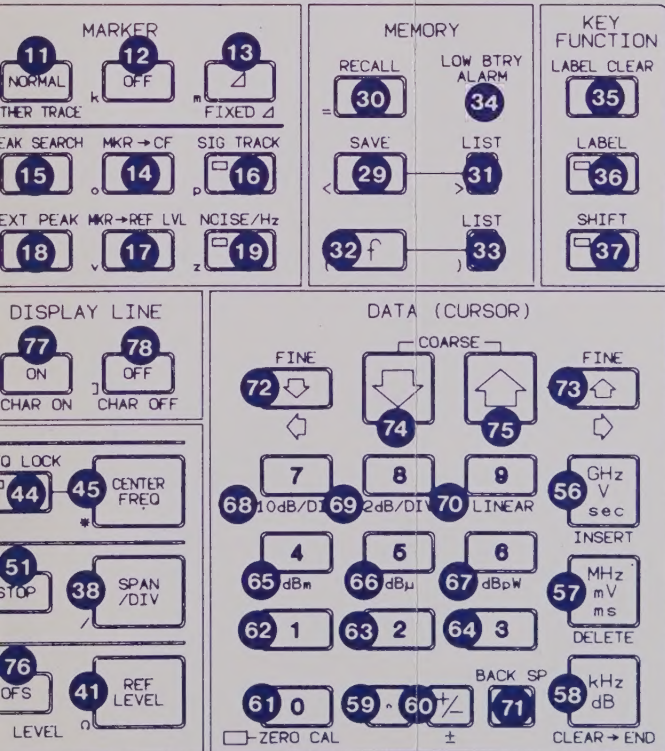


Appendix 1. GPIB codes corresponding to each key

ADVANTEST EXTERNAL KEYBOARD



TR41301





MP MASTER



MA22720

ADVANTEST

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